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# Metal Ion Release and Hypersensitivity Reactions Associated with Base Metal Alloys in Fixed and Removable Prosthodontics: A Narrative Review

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**KEYWORDS**

Base metal alloys; cobalt–chromium; nickel allergy; prosthodontics; corrosion; toxicology; hypersensitivity

**ABSTRACT:**

**Introduction**: Base metal alloys, especially cobalt–chromium (Co–Cr) and nickel–chromium (Ni–Cr), remain widely used in fixed and removable prosthodontics because of favorable mechanical strength, rigidity, wear resistance, and low cost. Despite these advantages, corrosion-mediated release of metallic ions in the oral cavity may pose chemical and biological health risks.

**Objectives**: This narrative review critically evaluates available evidence regarding metal ion release, toxicological implications, hypersensitivity reactions, clinical manifestations, diagnostic methods, and preventive strategies associated with base metal alloys used in prosthodontic treatment.

**Methods**: Relevant peer-reviewed literature including systematic reviews, in vitro investigations, clinical studies, and toxicological reports concerning dental base metal alloys was analyzed. Evidence relating to cobalt, chromium, nickel, corrosion behavior, oral exposure pathways, and immunologic responses was synthesized

**Results:** Ion release is influenced by alloy composition, manufacturing technique, surface roughness, salivary pH, fluoride exposure, galvanic interactions, thermal cycling, and biofilm activity. Nickel remains the most frequent sensitizer, whereas cobalt and chromium may contribute to oxidative stress, inflammatory responses, mucosal irritation, and delayed hypersensitivity. Clinical manifestations include burning mouth, lichenoid reactions, gingival inflammation, stomatitis, dermatitis, and prosthesis intolerance. Although most patients tolerate restorations satisfactorily, susceptible individuals may experience adverse reactions.

**Conclusions**: Base metal alloys continue to be valuable restorative materials; however, measurable chemical health risks exist in selected patients. Careful history taking, risk-based material selection, optimized finishing and polishing, regular maintenance, and use of alternative biomaterials when indicated are recommended.

## 1. Introduction

Dental biomaterials used in prosthodontics must provide structural durability, dimensional stability, corrosion resistance, esthetics, and biological compatibility. Base metal alloys have long been employed for fabrication of crowns, bridges, removable partial denture (RPD) frameworks, implant bars, clasps, attachments, and metal ceramic restorations because they are economical and possess superior mechanical properties compared with many noble alloys [1,2].

Among these materials, cobalt–chromium (Co–Cr) and nickel–chromium (Ni–Cr) systems are most widely used. Co–Cr alloys are preferred in removable prosthodontics because of their high modulus of elasticity, rigidity, and relatively low density. Ni–Cr alloys have historically been used in fixed prosthodontics because of good castability and compatibility with porcelain veneering systems [1,3].

However, concerns regarding corrosion, ion release, allergic reactions, and systemic toxicological effects have increased over recent decades. The oral cavity presents a dynamic electrochemical environment containing saliva, fluctuating pH, dietary acids, microbial metabolites, temperature changes, and mechanical stresses. These factors may degrade protective oxide layers on metal surfaces and cause release of cobalt, chromium, nickel, molybdenum, and other elements into saliva or surrounding tissues [4,5].

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Released ions may induce local inflammation, oxidative stress, cytotoxicity, genotoxicity, or delayed hypersensitivity reactions in susceptible patients [6–8]. With increasing use of CAD/CAM and additive manufacturing technologies, renewed interest exists in understanding whether newer fabrication methods improve or worsen corrosion behavior.

Therefore, this review aims to comprehensively summarize the current evidence concerning metal ion release and hypersensitivity reactions associated with base metal alloys in fixed and removable prosthodontics.

## 2. Methods and Materials

This article is a narrative review. Published literature related to dental base metal alloys, corrosion, ion release, allergy, hypersensitivity, and toxicological effects in prosthodontics was evaluated. Sources included peer-reviewed journal articles, systematic reviews, clinical reports, and laboratory studies indexed in recognized biomedical databases. Priority was given to studies involving cobalt–chromium, nickel–chromium, corrosion mechanisms, oral biocompatibility, and prosthodontic clinical relevance.

## 3. Composition and Properties of Base Metal Alloys

Base metal alloys contain less noble metallic constituents and rely on passivating oxide layers for corrosion resistance.

### 3.1 Cobalt–Chromium Alloys

Typical Co–Cr alloys contain cobalt, chromium, molybdenum, tungsten, manganese, silicon, and trace carbon. Chromium forms a passive oxide film that improves corrosion resistance. These alloys possess high strength, stiffness, wear resistance, and low density [2,9].

### 3.2 Nickel–Chromium Alloys

Ni–Cr alloys usually contain nickel, chromium, molybdenum, and minor additions such as beryllium in older formulations. They exhibit acceptable castability and thermal compatibility with porcelain. However, nickel sensitization remains a major concern [1,10].

### 3.3 Other Base Metal Systems

Titanium and titanium alloys are increasingly used in prosthodontics and implantology due to superior biocompatibility. Stainless steel and specialty alloys have limited indications.

**Table 1. Common Base Metal Alloys Used in Prosthodontics**

| Alloy Type | Principal Components | Common Uses | Main Concerns |
|---|---|---|---|
| Co–Cr | Co, Cr, Mo, W | RPD frameworks, bars, crowns | Co/Cr ion release |
| Ni–Cr | Ni, Cr, Mo | Crowns, bridges | Nickel hypersensitivity |
| Ni–Cr–Be | Ni, Cr, Be | Older metal ceramic systems | Be toxicity, allergy |
| Titanium alloys | Ti-based | Implants, frameworks | Rare hypersensitivity |

## 4. Corrosion and Metal Ion Release in the Oral Cavity

### 4.1 Electrochemical Corrosion

Corrosion is the gradual deterioration of metal due to chemical or electrochemical interaction with the environment. Saliva acts as an electrolyte and may facilitate anodic dissolution of metals [4].

### 4.2 Breakdown of Passive Films

Chromium oxide passivation normally protects Co–Cr and Ni–Cr alloys. Surface scratches, plaque acids, low pH, or fluoride compounds may damage this protective film, exposing reactive metal [5,11].

### 4.3 Galvanic Corrosion

When dissimilar metallic restorations coexist intraorally, galvanic currents may develop. This accelerates corrosion and may cause metallic taste or discomfort.

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### 4.4 Fretting and Wear Corrosion

Repeated clasp movement in RPDs, occlusal wear, insertion/removal cycles, and micro-motion at interfaces can abrade the surface and increase ion release [12].

**Table 2. Factors Influencing Metal Ion Release**

| Factor | Effect on Ion Release |
|---|---|
| Low salivary pH | Increases corrosion |
| Surface roughness | Increases reactive area |
| Fluoride agents | May damage oxide layer |
| Thermal cycling | Promotes microstructural stress |
| Galvanic coupling | Accelerates dissolution |
| Plaque biofilm | Produces acidic metabolites |
| Poor polishing | Increases release |
| Mechanical wear | Exposes fresh metal |

## 5. Evidence from Experimental Studies

Several studies have demonstrated measurable release of cobalt, chromium, and nickel ions into artificial saliva or buffer media. Lucchetti et al. found detectable ion release from Co–Cr dental alloys depending on immersion medium and surface condition [13]. Pangi et al. reported release of multiple elements from base metal alloys in artificial saliva and phosphate-buffered saline, indicating that environmental composition strongly influences corrosion behavior [14].

Mercieca et al. showed that acidic environments increased corrosion susceptibility of cast cobalt- and nickel-chromium alloys [15]. Jafari et al. observed nickel ion release in different mouthwashes, emphasizing that oral hygiene products may alter metal behavior [16].

Recent manufacturing comparisons suggest that cast, milled, laser-sintered, and 3D-printed Co–Cr alloys exhibit different microstructures and corrosion responses [17,18]. While some digitally manufactured alloys show improved homogeneity, porosity and residual stresses may also affect performance.

## 6. Toxicological Effects of Released Metal Ions

### 6.1 Cobalt Toxicity

Cobalt ions may generate reactive oxygen species, interfere with mitochondrial function, and stimulate inflammatory mediators. Excessive exposure has been associated with cytotoxicity in cell models [6].

### 6.2 Chromium Toxicity

Chromium in dental alloys is generally present in stable forms that aid passivation. Nevertheless, released chromium species may contribute to oxidative damage and tissue irritation under adverse conditions [6,19].

### 6.3 Nickel Toxicity

Nickel is one of the most recognized metal sensitizers worldwide. Even relatively low concentrations may trigger reactions in previously sensitized individuals [8,10].

### 6.4 Local Oral Effects

Possible oral manifestations include:

- Mucosal erythema
- Burning sensation

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- Ulceration
- Gingival inflammation
- Altered taste
- Lichenoid lesions
- Tissue soreness under prostheses

**7. Hypersensitivity Reactions**

Metal hypersensitivity is primarily a delayed type IV cell-mediated immune reaction. Released ions act as haptens and bind host proteins, creating antigenic complexes recognized by T lymphocytes [8].

Nickel has the highest prevalence of sensitization, followed by cobalt and chromium. Previous exposure through jewellery, occupational contact, or consumer products may predispose patients to oral reactions.

**7.1 Clinical Manifestations**

- Burning mouth symptoms
- Contact stomatitis
- Perioral dermatitis
- Gingivitis adjacent to restorations
- Lichenoid mucosal lesions
- Persistent intolerance to metal prostheses
- Rare unexplained peri-implant inflammation

Table **3. Clinical Signs Suggestive of Metal Hypersensitivity**

| Clinical Finding | Possible Relevance |
|---|---|
| Burning mouth | Metal sensitivity |
| Localized lichenoid lesion | Adjacent alloy restoration |
| Gingival inflammation | Corrosion products |
| Dermatitis after insertion | Systemic sensitivity |
| Chronic soreness under RPD | Framework intolerance |

**8. Fixed Prosthodontics Considerations**

Ni–Cr and Co–Cr alloys are commonly used in metal ceramic crowns and bridges. Subgingival margins may prolong contact between released ions and gingival crevicular tissues. Poorly finished margins may increase plaque retention and localized inflammation.

Patients with known nickel allergy should preferably avoid Ni-containing fixed restorations. Contemporary alternatives include zirconia, lithium disilicate, titanium, or noble alloys when feasible.

**9. Removable Prosthodontics Considerations**

Co–Cr remains the standard material for many RPD frameworks because of rigidity and thin-section strength. However, repeated clasp flexure, abrasion, and salivary stagnation beneath connectors may increase local corrosion potential [2].

Well-designed frameworks with polished surfaces, adequate hygiene access, and periodic recall appointments can reduce complications.

**10. Diagnostic Approach**

**10.1 History Taking**

A detailed history is essential:

- Jewellery allergy
- Skin reactions to metal objects
- Prior intolerance to restorations
- Timing of symptoms after insertion

**10.2 Clinical Examination**

Evaluate lesion location, prosthesis fit, hygiene status, occlusion, trauma, and differential diagnoses.

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### 10.3 Patch Testing

Patch tests may help identify nickel, cobalt, or chromium sensitivity.

### 10.4 Lymphocyte Transformation Test

May assist in selected complex cases or suspected implant-related hypersensitivity [20].

### 10.5 Differential Diagnosis

Exclude:

- Candidiasis
- Mechanical trauma
- Xerostomia
- Burning mouth syndrome
- Galvanic pain
- Lichen planus
- Poor prosthesis fit

## 11. Risk Mitigation and Prevention

1. Obtain allergy history before treatment.
2. Avoid Ni-containing alloys in sensitized patients.
3. Prefer high-quality Co–Cr, titanium, zirconia, or ceramic alternatives when indicated.
4. Use precise manufacturing protocols.
5. Finish and polish all metal surfaces thoroughly.
6. Avoid unnecessary mixed-metal combinations.
7. Maintain oral hygiene and regular recalls.
8. Replace offending restorations when clinically justified.

**Table 4. Material Selection Guidance**

| Patient Profile | Suggested Material |
|---|---|
| Known nickel allergy | Titanium / zirconia / noble alloy |
| RPD needing rigidity | Co–Cr |
| High esthetic zone | All-ceramic |
| Multiple allergies | Titanium / metal-free |
| Heavy occlusion | Carefully selected metal framework |

## 12. Emerging Technologies

CAD/CAM milling and additive manufacturing (selective laser melting / 3D printing) are increasingly used for Co–Cr frameworks and prostheses. These methods may improve fit and reduce casting defects; however, surface finishing remains critical. Long-term comparative clinical data are still limited [17,18].

## 13. Results and Discussion

Available evidence confirms that base metal alloys can release measurable metallic ions under simulated and clinical oral conditions. The extent of release depends strongly on material composition, oral environment, and manufacturing quality. Most exposures are low and clinically tolerated; however, chronic local contact and patient susceptibility determine biological significance.

Nickel remains the principal allergenic concern. Co–Cr alloys generally demonstrate better corrosion resistance than many older Ni–Cr systems due to chromium passivation, but they are not completely inert. Additive manufacturing technologies show promise, yet standardization is required.

From a chemical health risk perspective, the clinician must balance mechanical benefits against biocompatibility. Personalized material selection is increasingly important.

## 14. Conclusion

Base metal alloys continue to play an important role in fixed and removable prosthodontics because of affordability and favorable mechanical performance. Nonetheless, corrosion-mediated release of cobalt, chromium, nickel, and associated ions may contribute to local toxicity or hypersensitivity in susceptible individuals. Nickel remains the most common sensitizer, while cobalt and chromium may also induce adverse tissue responses. Thorough patient assessment, informed material selection, optimized finishing, and regular follow-up can significantly reduce risk. Future research should emphasize standardized in vivo exposure models and patient-specific biomaterial strategies.

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None.

**Conflict of Interest**

The authors declare no conflict of interest.

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